### Space DA

#### Effective space ex is only possible with nuclear power.

Newhall 15 Marissa (Director of Digital Strategy and Communications) “History of Space Nuclear Power” June 9th 2015 <http://energy.gov/articles/history-nuclear-power-space> JW

You may not associate space travel with the Energy Department. But you should -- because nuclear power systems developed here have made dozens of truly amazing interplanetary research missions possible. The Energy Department’s Office of Space and Defense Power Systems and its predecessors, in tandem with the National Labs and private industry partners, have developed and provided radioisotope power systems to NASA for use in numerous long-term missions, from Voyagers 1 and 2 to the Mars rovers. These compact, reliable systems provide basic mission fuel and keep critical spacecraft components warm enough to function in the cold, dark reaches of deep space. Although relatively simple, these systems have powered some of the most successful and inspiring missions in U.S. space program history. Explore our interactive timeline of these missions, above, and read on to learn more about the “space batteries” that made them a reality. POWER FROM PLUTONIUM Despite what you see in movies and TV shows, there are only two practical ways to supply electrical power for multi-year space missions: the sun’s rays or heat generated by natural radioactive decay. Radioisotope power systems -- which directly convert heat generated by the decay of plutonium-238 into electric power -- use the latter, and are essential for long missions to distant parts of the solar system, where solar-powered space travel may be impractical or impossible. Plutonium-238 works well as a space power source for several reasons. It has a half-life of 88 years, meaning it takes that long for its heat output to be reduced by half. It’s stable at high temperatures; can generate substantial heat in small amounts; and emits relatively low levels of radiation that is easily shielded, so mission-critical instruments and equipment are not affected. This type of plutonium is different than those used for nuclear weapons or nuclear power plant reactors.

#### Preserving the ability to colonize space outweighs every other impact – 10^14 human lives are lost every second we delay.

Bostrom 3 Nick (Swedish philosopher at the University of Oxford known for his work on existential risk, the anthropic principle, human enhancement ethics, superintelligence risks, the reversal test, and consequentialism) “Astronomical Waste: The Opportunity Cost of Delayed Technological Development” Utilitas Vol. 15, No. 3 (2003): pp. 308-314 <http://www.nickbostrom.com/astronomical/waste.html> JW

I. THE RATE OF LOSS OF POTENTIAL LIVES As I write these words, suns are illuminating and heating empty rooms, unused energy is being flushed down black holes, and our great common endowment of negentropy is being irreversibly degraded into entropy on a cosmic scale. These are resources that an advanced civilization could have used to create value-structures, such as sentient beings living worthwhile lives. The rate of this loss boggles the mind. One recent paper speculates, using loose theoretical considerations based on the rate of increase of entropy, that the loss of potential human lives in our own galactic supercluster is at least ~10^46 per century of delayed colonization.[1] This estimate assumes that all the lost entropy could have been used for productive purposes, although no currently known technological mechanisms are even remotely capable of doing that. Since the estimate is meant to be a lower bound, this radically unconservative assumption is undesirable. We can, however, get a lower bound more straightforwardly by simply counting the number or stars in our galactic supercluster and multiplying this number with the amount of computing power that the resources of each star could be used to generate using technologies for whose feasibility a strong case has already been made. We can then divide this total with the estimated amount of computing power needed to simulate one human life. As a rough approximation, let us say the Virgo Supercluster contains 10^13 stars. One estimate of the computing power extractable from a star and with an associated planet-sized computational structure, using advanced molecular nanotechnology[2], is 10^42 operations per second.[3] A typical estimate of the human brain’s processing power is roughly 10^17 operations per second or less.[4] Not much more seems to be needed to simulate the relevant parts of the environment in sufficient detail to enable the simulated minds to have experiences indistinguishable from typical current human experiences.[5] Given these estimates, it follows that the potential for approximately 10^38 human lives is lost every century that colonization of our local supercluster is delayed; or equivalently, about 10^29 potential human lives per second. While this estimate is conservative in that it assumes only computational mechanisms whose implementation has been at least outlined in the literature, it is useful to have an even more conservative estimate that does not assume a non-biological instantiation of the potential persons. Suppose that about 10^10 biological humans could be sustained around an average star. Then the Virgo Supercluster could contain 10^23 biological humans. This corresponds to a loss of potential equal to about 10^14 potential human lives per second of delayed colonization. What matters for present purposes is not the exact numbers but the fact that they are huge. Even with the most conservative estimate, assuming a biological implementation of all persons, the potential for one hundred trillion potential human beings is lost for every second of postponement of colonization of our supercluster.[6] II. THE OPPORTUNITY COST OF DELAYED COLONIZATION From a utilitarian perspective, this huge loss of potential human lives constitutes a correspondingly huge loss of potential value. I am assuming here that the human lives that could have been created would have been worthwhile ones. Since it is commonly supposed that even current human lives are typically worthwhile, this is a weak assumption. Any civilization advanced enough to colonize the local supercluster would likely also have the ability to establish at least the minimally favorable conditions required for future lives to be worth living. The effect on total value, then, seems greater for actions that accelerate technological development than for practically any other possible action. Advancing technology (or its enabling factors, such as economic productivity) even by such a tiny amount that it leads to colonization of the local supercluster just one second earlier than would otherwise have happened amounts to bringing about more than 10^29 human lives (or 10^14 human lives if we use the most conservative lower bound) that would not otherwise have existed. Few other philanthropic causes could hope to mach that level of utilitarian payoff.

### Get the heck off the rock!

#### Extinction’s inevitable on earth – space col solves multiple existential threats.

Davies 10 Dirk Schulze-Makuch (School of Earth and Environmental Sciences, Washington State University) and Paul Davies (Beyond Center, Arizona State University) “To Boldly Go: A One-Way Human Mission to Mars” Journal of Cosmology, 2010, Vol 12, 3619-3626. <http://journalofcosmology.com/Mars108.html> JW

There are several reasons that motivate the establishment of a permanent Mars colony. We are a vulnerable species living in a part of the galaxy where cosmic events such as major asteroid and comet impacts and supernova explosions pose a significant threat to life on Earth, especially to human life. There are also more immediate threats to our culture, if not our survival as a species. These include global pandemics, nuclear or biological warfare, runaway global warming, sudden ecological collapse and supervolcanoes (Rees 2004). Thus, the colonization of other worlds is a must if the human species is to survive for the long term. The first potential colonization targets would be asteroids, the Moon and Mars. The Moon is the closest object and does provide some shelter (e.g., lava tube caves), but in all other respects falls short compared to the variety of resources available on Mars. The latter is true for asteroids as well. Mars is by far the most promising for sustained colonization and development, because it is similar in many respects to Earth and, crucially, possesses a moderate surface gravity, an atmosphere, abundant water and carbon dioxide, together with a range of essential minerals. Mars is our second closest planetary neighbor (after Venus) and a trip to Mars at the most favorable launch option takes about six months with current chemical rocket technology.

#### Extinction is inevitable on earth.

Kaplan 15 Sarah (reporter for Washington Post) “Earth is on brink of a sixth mass extinction, scientists say, and it’s humans’ fault” Washington Post June 22nd 2015 <https://www.washingtonpost.com/news/morning-mix/wp/2015/06/22/the-earth-is-on-the-brink-of-a-sixth-mass-extinction-scientists-say-and-its-humans-fault/> JW

A vast chunk of space rock crashes into the Yucatan Peninsula, darkening the sky with debris and condemning three-quarters of Earth’s species to extinction. A convergence of continents disrupts the circulation of the oceans, rendering them stagnant and toxic to everything that lives there. Vast volcanic plateaus erupt, filling the air with poisonous gas. Glaciers subsume the land and lock up the oceans in acres of ice. Five times in the past, the Earth has been struck by these kinds of cataclysmic events, ones so severe and swift (in geological terms) they obliterated most kinds of living things before they ever had a chance to adapt. Now, scientists say, the Earth is on the brink of a sixth such “mass extinction event.” Only this time, the culprit isn’t a massive asteroid impact or volcanic explosions or the inexorable drifting of continents. It’s us. Humans’ staggering effect on Earth View Photos Images of consumption are the theme of the book, “Overdevelopment, Overpopulation, Overshoot.” It addresses environmental deterioration through subjects including materialism, consumption, pollution, fossil fuels and carbon footprints. “We are now moving into another one of these events that could easily, easily ruin the lives of everybody on the planet,” Stanford biologist Paul Ehrlich said in a video created by the school. In a study published Friday in the journal Science Advances, biologists found that the Earth is losing mammal species 20 to 100 times the rate of the past. Extinctions are happening so fast, they could rival the event that killed the dinosaurs in as little as 250 years. Given the timing, the unprecedented speed of the losses and decades of research on the effects of pollution, hunting and habitat loss, they assert that human activity is responsible. “The smoking gun in these extinctions is very obvious, and it’s in our hands,” co-author Todd Palmer, a biologist at the University of Florida, wrote in an e-mail to The Washington Post. [Release of encyclical reveals pope’s deep dive into climate science] Since 1900 alone, 69 mammal species are believed to have gone extinct, along with about 400 other types of vertebrates. Evidence for species lost among nonvertebrate animals and other kinds of living things is much more difficult to come by, the researchers say, but there’s little reason to believe that the rest of life on Earth is faring any better. This rapid species loss is alarming enough, according to the study’s authors, but it could be just the beginning. “We can confidently conclude that modern extinction rates are exceptionally high, that they are increasing, and that they suggest a mass extinction under way,” they write. “If the currently elevated extinction pace is allowed to continue, humans will soon (in as little as three human lifetimes) be deprived of many biodiversity benefits.”

### AT “Mars Colonization Impossible”

#### Mars colonization is possible – the resources are there and the environment is suitable

**Hender 10** – University of Adelaide, School of Mechanical Engineering (Matthew “Colonization: a permanent habitat for the colonization of Mars” <http://digital.library.adelaide.edu.au/dspace/handle/2440/61315>

It has been demonstrated, through numerous measurements, observations and investigations, that Mars contains all of the essential elements for the maintenance of life and sustenance of an established habitat.

Virtually every region of Mars has been proposed as being suitable for locating a habitat, from the poles to the equator, above or below ground, each with its own advantages and disadvantages, and each being viable for various proposed designs. Regional characteristics, such as temperature, wind speed, dist storms and ground conditions must all be considered in any design. Particularly, a renewable supply of water is essential. Further, the method, and materials, or fabrication must be considered; utilizing local materials, or imported; constructed or inflated,; also considering things such as radiation protection, safety, living space, insulation, ease and speed of insulation and redundancy. Facilities required in the habitat include those necessary foe living, recreation and working. Living facilities include life support systems, sleeping environments, meal preparation and ablution facilities and other such areas. Recreational facilities include lounge and reading areas, entertainment facilities and other such facilities to allow relaxation and diversional activities. Working facilities will include laboratories, office space, industrial areas( power generation, etc.) workshops, food and other production areas. Power supply options on Mars are many. Depending upon the power demand of facilities, which varies with the population and industrial requirements. Nuclear is considered to be the most viable, due to the reliability and the power generation capability, however, this will require resupply of nuclear fuel, launched from Earth, and has environmental and safety considerations associated. Solar (surface or orbital), wind and possible geothermal energy sources appear to be reliable and viable systems of power supply, although each has its drawbacks. Options for power storage must also be considered, including fuel cells or natural gas (such storage of power is through the manufacture of the fuel, hydrogen or methane, respectively). Emergency power generation, through mechanical (human-powered) or other means, must also be provided. All significant materials required to support life and industry are believed to exist on Mars. Processes for mining, extraction or concentration, as may be required must be developed and proven, however, this is considered feasible. Renewable water and atmosphere constituent sources are considered critical, as are nutrients necessary for the production of food.

#### We can terraform Mars

**Hawkes 92** (Nigel, writer at The London Times, The London times, January 25, “Planet X marks the spot”, lexis)

Thanks to the Mariner and Viking series of spacecraft, we now know that Mars has been shaped by many of the same processes as Earth. It has seasons, clouds, polar icecaps, strong winds and active volcanoes, and once was so warm and wet that rivers carved out channels across its surface. Now the water has gone, some of it frozen into ice at the poles, where the temperature is cold enough to freeze not only water but also carbon dioxide. It is the ebb and flow of these white polar caps, created by the formation and evaporation of dry ice, that so excited the astronomers of old. At the equator, the temperature varies from a tolerable 26C at noon to a penetrating -111C just before sunrise. Although the Viking landers found no evidence of life past or present, Mars is after Earth by far the closest the solar system comes to a habitable planet. It would be feasible to establish colonies on Mars, living inside domes that could create an artificial atmosphere and provide a screen against incoming solar radiation. Mars has no ozone layer, so its surface is bombarded by lethal amounts of ultraviolet light. Mars was once a much warmer and wetter planet than it is today. In 1952, Arthur C.Clarke, the science-fiction writer, in his book The Sands of Mars, envisaged a colony that was starved of support from Earth and set out to transform the entire planet. The idea has recently been given fresh impetus by Christopher McKay and his colleagues at Ames, who have conducted a feasibility study. The main uncertainty in their calculations, which only further exploration can answer, is whether the main components needed to form an Earth-like atmosphere water, carbon dioxide and nitrogen exist in sufficient quantities on Mars. Assuming they do, then all that is needed to begin the process of breathing life on Mars is to warm up the planet, so that the icecaps melt to provide water and carbon dioxide. According to McKay, this can be done by the same process that is responsible for warming Earth. Large quantities of ''greenhouse gases'', such as the chlorofluorocarbons (CFCs) blamed for global warming, would be injected into the Martian atmosphere. The amount of warming needed is about 60C, to bring Mars to a temperature range of between 0C and 30C, comparable to that of Earth. To achieve such an increase, some 40 billion tons of CFCs would need to be injected into the Martian atmosphere too much, McKay concedes, to be carried there from Earth. It would have to be produced in factories, large enough to make 100 million tons of CFCs a year, on the planet's surface. The raw materials to supply such factories probably exist on Mars. Even so, CFCs alone would probably not be enough. They might be aided by warming the poles with huge mirrors in space, reflecting sunlight on to them, or by scattering black soot over the icecaps so that they absorbed more heat. The hope is that by using one or more of these techniques, the temperature would begin to rise and a runaway greenhose effect would be created by the huge stores of carbon dioxide and water in the polar icecaps. A small increase in temperature would release large amounts of both materials, creating further rises in temperature. The process, once started, should become self-sustaining. In due course say 100 years this would produce a damp, carbon dioxide-rich atmosphere in which some plants could flourish.

### Nuke power key

#### Nuclear power is key to space missions.

Bryner 15 Jeanna (Live Science Managing Editor) “Space Fuel: Plutonium-238 Created After 30-Year Wait” December 30th 2015 Live Science <http://www.livescience.com/53227-plutonium-238-created-for-space-fuel.html> JW

Scientists have produced a powder of plutonium-238 for the first time in nearly 30 years in the United States, a milestone that they say sets the country on a path toward powering NASA's deep-space exploration and other missions. Plutonium-238 (Pu-238) is a radioactive element, and as it decays, or breaks down into uranium-234, it releases heat. That heat can then be used as a power source; for instance, some 30 space missions, including the Voyager spacecraft, which explored the solar system's outer planets in the 1970s, have relied on the oxide form of the plutonium isotope. (An isotope is atom of an element with a different number of neutrons.) During the Cold War, the Savannah River Plant in South Carolina was pumping out Pu-238. "Those reactors were shut down in 1988, and the U.S. has not had the capability to make new material since then," said Bob Wham, who leads the project for the Nuclear Security and Isotope Technology Division at the Department of Energy's Oak Ridge National Laboratory (ORNL). [8 Rare Elements That You've Never Heard Of] After U.S. production of the isotope stopped, Russia supplied the Pu-238 needed for space missions. However, Russia has also stopped producing the material. Two years ago, NASA began funding a new effort to produce plutonium-238, giving about $15 million a year to the DOE Office of Nuclear Energy. Plutonium-238 is an ideal power source for space missions for several reasons, including the element's so-called half-life of about 88 years. Half-life is the time it takes for half of the atoms of an element to decay. That means the isotope's heat output won't be reduced to half for 88 years. Plutonium-239, which has a half-life of 24,110 years, is the isotope most commonly formed from uranium in nuclear reactors, according to the World Nuclear Association. In addition, "it's stable at high temperatures, can generate substantial heat in small amounts and emits relatively low levels of radiation that is easily shielded, so mission-critical instruments and equipment are not affected," Wham said. In the new achievement, Wham and his colleagues created 50 grams (1.8 ounces) of Pu-238 - about one-eighth of a cup (30 milliliters) - or enough to characterize the substance, he said. Because the scientists were using existing infrastructure at the Department of Energy, they needed to adapt the plutonium-making process. "For example, the current DOE operating research reactors are smaller than those used at Savannah River," Wham said. "Therefore, we need to modify the technology to work within the existing operating reactors." Next, the scientists will test the purity of the sample and work on scaling up the manufacturing process. "Once we automate and scale up the process, the nation will have a long-range capability to produce radioisotope power systems such as those used by NASA for deep-space exploration," Wham said. The next NASA mission with a plan to use such radioisotope power is the Mars 2020 rover, set for launch in July 2020, the researchers said. The rover will be designed to look for signs of life on the Red Planet, collect rock and soil samples for testing on Earth, and investigate technology for human exploration.

### K2 Mars

#### Key to mars exploration Rudo 3:

Nuclear Propulsion and What It Means to Space ExplorationSTANDARD END written by Brian Rudo on March 05, 2003 http://www.redcolony.com/art.php?id=0303050#Nuclear\_Propulsion\_and\_What\_It\_Means\_to\_Space\_Exploration

Also at times called nuclear rocketry is another, more practical method that uses propellant, such as hydrogen, heated to extreme temperatures and ejected at high velocities as in a conventional rocket. **Unlike a conventional rocket**, the propellant’s **energy would come from** direct or **indirect nuclear energy, and thus be extremely more powerful**. This design, usually called **nuclear thermal propulsion**, has many supporters. It **would allow very fast changes in velocities**, **and would be able to make a trip to Mars in a few days at its most advanced form**. **It also has use in rover missions and even in a unique concept called a hopper, which would be able to use Martian atmosphere to propel itself from site to site to conduct research.** An advantage of this system lies in the fact that although some gases are better, any gas will do for propulsion. This means that a **craft on Mars could use the indigenous Martian atmosphere or water ice to refuel, extending its lifetime and reducing cost and increasing efficiency by orders of magnitudes**. The United States and the former Soviet Union have both successfully built full-scale functioning rocket engines using nuclear thermal propulsion.